

# Technical Memorandum

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<b>To:</b>	Javier Toro Rosemont Copper Company Tucson, Arizona	<b>Project No:</b>	1720214024
<b>By:</b>	Rachel Peterson	<b>Reviewed by:</b>	Peter Yuan, PE
<b>Tel:</b>	(602) 733-6000	<b>CC:</b>	File
<b>Date:</b>	December 1, 2021		
<b>Re:</b>	<b>Heap Leach Liner Chemical Compatibility Rosemont Copper World Project</b>		

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## 1.0 Introduction and Objectives

Wood Environment and Infrastructure Solutions, Inc. (Wood) has prepared this technical memorandum for Rosemont Copper Company (Rosemont) to address chemical compatibility of the proposed heap leach liner system for the Rosemont Copper World Project (Project) to the Best Available Demonstrated Control Technology (BADCT) Prescriptive requirements set forth in the Arizona Department of Environmental Quality's (ADEQ) "Arizona Mining Guidance Manual BADCT" (ADEQ Publication Number TB-04-01).

The use of BADCT to minimize the impacts to groundwater is required by ADEQ to obtain an Aquifer Protection Permit (APP) for the planned heap leach facility (HLF). BADCT is to be applied throughout the entire facility life cycle including design, construction, operation and closure. Engineering analyses were performed in general accordance with requirements for the APP, Arizona Revised Statute (A.R.S.) 49-243.B.1 and followed the individual BADCT criteria. The following sections provide a summary and assessment of the chemical compatibility of material associated with the proposed design of the heap leach liner system.

## 2.0 Design Elements

In lined areas of the HLF, the liner will consist of the following components from bottom to top (as shown in Figure 1):

- The leach pad is proposed to be divided into several cells which will be constructed on placed and compacted (engineer-controlled) waste rock overlain with a protective layer under the Liner Bedding Material. The waste rock will be placed to create a drainage pattern to the centerline of the pad and then toward the west side at an overall design grade of 3 percent (%) or steeper, from the west side of the pad.
- Under-liner or Liner Bedding Material: A layer of geosynthetic clay liner (GCL) is currently planned.
- The under-liner is overlain by a geomembrane: The geomembrane will consist of 80-mil double sided textured linear low-density polyethylene (LLDPE).

- The overliner will consist of a three-foot (ft) thick layer of a well-draining material installed over the geomembrane. The overliner material will be obtained from processed ore consisting of 1.5-inch minus rock with a hydraulic conductivity of  $1 \times 10^{-1}$  centimeters per second (cm/sec) as specified in the Project Design Criteria. There will also be a series of perforated solution collection pipes directly above the geomembrane which will be sized and spaced to allow a hydraulic head of less than two-ft on average, with a maximum hydraulic head of five-ft.

## **2.1 Overliner Drain**

The heap leach overliner drain rock is proposed to consist of a three-foot thickness of processed drainage material (clean crushed rock), with 100 percent (%) passing a 1.5-inch screen. The function of this layer is to protect the geomembrane from damage that might occur from construction or operations activities, and to collect leachate drainage from the overlying heap, thus limiting hydraulic head on the geomembrane liner.

## **2.2 LLDPE Geomembrane**

An 80-mil (2.0 millimeters) linear low-density polyethylene (LLDPE) geomembrane liner has been selected for the leach pad, based on engineering performance requirements, and past design and construction experience. The pad liner will have double textured surfaces to enhance the heap leach stability and the safety of construction workers working on the liner in irregular terrain. LLDPE provides superior puncture resistance compared to high-density polyethylene (HDPE). An 80-mil liner was deemed adequate based on site-specific liner puncture testing for the Project (Wood, 2021).

## **2.3 Geosynthetic Clay Liner (GCL)**

A sodium bentonite GCL was selected for the low-permeability layer in the liner system for the leach pad and pond liner system. The GCL liner provides the equivalent of a one-foot minimum thickness of  $1 \times 10^{-6}$  cm/sec or lower permeability soil layer.

## **3.0 Geochemical Compatibility**

Geochemical compatibility with leachate was assessed for both the proposed geomembrane liner and for the bentonite GCL product. Technical literature of the plastic resins indicates that sulfuric acid in the concentrations that will be present in the heap (approximately 0.5% concentration) will have little or no effect on the proposed geomembrane liner. A technical note inclusive of a chemical resistance chart for the Chevron Phillips Chemical Company LP Marlex® polyethylene resins used in the manufacturing of the proposed AGRU geomembrane liner is provided in Attachment A.

Low pH and high ionic strength solutions can influence hydraulic conductivity and performance of the sodium bentonite within the GCL. However, these effects are minimal under high confining pressures and low acid level conditions. The anticipated confining pressures for the heap leach pad (HLP) are above those shown to minimize the GCL performance of acidic and high ionic strength solutions on sodium bentonite (Thiel and Criley, 2005).

#### **4.0 References**

Thiel, R. and Criley, K., 2005, Hydraulic Conductivity of a GCL Under Various High Effective Confining Stresses for Three Different Leachates, Presented at Geofrontiers 2005, Waste Containment and Remediation

Wood, 2021. Geotechnical Site Investigation Memorandum, Heap Leach, Tailings and Waste Rock Facilities December 1.

#### **Figure:**

Figure 1 - Heap Leach Pad Liner System Detail

#### **Attachments:**

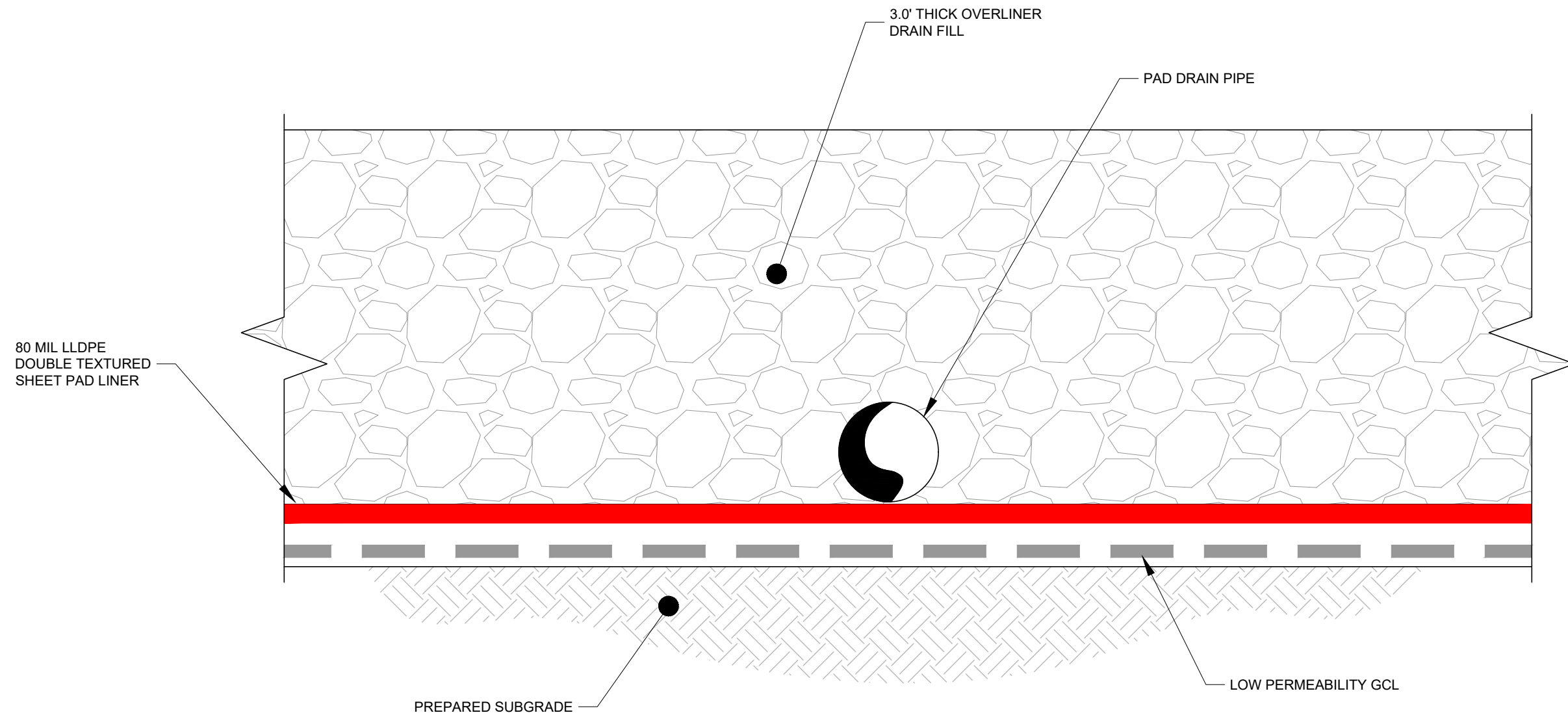
Attachment A - Chevron Phillips Chemical Company LP Marlex® Polyethylene Packing Properties

## **ACRONYMS AND ABBREVIATIONS**

%	Percent
ADEQ	Arizona Department of Environmental Quality
APP	Aquifer Protection Permit
A.R.S.	Arizona Revised Statute
BADCT	Best Available Demonstrated Control Technology
cm/sec	Centimeters per Second
GCL	Geosynthetic Clay Liner
HDPE	High-Density Polyethylene
HLF	Heap Leach Facility
HLP	Heap Leach Pad
LLDPE	Linear Low-Density Polyethylene
mil	One Thousandth of an Inch
Project	Rosemont Copper World Project
Rosemont	Rosemont Copper Company
Wood	Wood Environment & Infrastructure Solutions, Inc.

**Figure**

Drawing Path: P:\2021\Projects\_Other\1720214024.001\_Rosemont Project\13\_CAD\03\_Figures\002 - 19 - 11-2021 - Heap Leach Pad Liner.dwg Plot Date: 11/19/21 - 9:15am



**DETAIL - HEAP LEACH  
PAD LINER SYSTEM**  
SCALE: N.T.S.

ROSEMONT COPPER WORLD PROJECT  
HEAP LEACH PAD LINER SYSTEM  
DETAIL

**wood.**  
WOOD ENVIRONMENT & INFRASTRUCTURE SOLUTIONS  
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PHOENIX, ARIZONA 85034  
PHONE: 602-733-6000

Figure:

1

By: GG

Date: 19/11/21

Project No: 17-2021-4024

**Attachment A: Chevron Phillips Chemical Company LP Marlex® Polyethylene  
Packing Properties**

## PE TIB-2

## PACKAGING PROPERTIES

### INTRODUCTION

The growth of plastic materials into the packaging market has been phenomenal in recent years. The versatility and design flexibility of high density polyethylene (HDPE) lends itself to injection molded, blow molded, extruded and rotationally molded applications. Technological developments such as coextrusion with barrier resins allow packages to be tailored to meet product-specific requirements, thus expanding the market at an ever-increasing rate.

Chevron Phillips Chemical Company LP (Chevron Phillips Chemical) has provided almost 50 years of plastic product development and processing expertise to the packaging industry. Marlex<sup>®</sup> high density polyethylene resins from Chevron Phillips Chemical continue to offer the excellent balance of physical and chemical properties needed for packaging applications: toughness, chemical resistance, gas/liquid permeation resistance and environmental stress-crack resistance. Realizing the increasing demands being placed on packaging materials by the proliferation of new products, Chevron Phillips Chemical continues to work closely with the packaging industry to develop improved Marlex<sup>®</sup> HDPE resins.

The feasibility of packaging a product in any plastic container depends heavily on the shelf life and display conditions to which it will be subjected. The only way to ensure the suitability of any package/product combination is to test it under



Top-load testing of Marlex<sup>®</sup> HDPE containers

representative conditions. Most resin suppliers and processors are equipped to evaluate the effect of the product on the package, but any evaluation of changes to the product itself requires specialized expertise, and generally must be tested by the manufacturer of that product.



## PACKAGING PROPERTIES

The suitability of Marlex® HDPE for packaging applications is related to the density, melt index and molecular weight distribution of the resin. As the density increases, for example, the stiffness, softening temperature, resistance to permeation, and chemical resistance of the finished item will increase. Conversely, when melt index decreases, impact strength (toughness) will increase. Environmental stress-crack resistance (ESCR) is dependent on molecular weight distribution as well as density and melt index. In any one resin series, when density is constant, ESCR improves as the melt index decreases.

Marlex® HDPE molding and extrusion grade resins meet specifications published in the Federal Register by the Food and Drug Administration. The critical guidelines are covered in their document 21 CFR 177.1520.

Although it is difficult to recommend a particular grade of Marlex® HDPE for packaging applications without knowing the use environment, the following guidelines can assist in resin selection:

1. High melt index (lower molecular weight) resins are recommended for injection molded containers, due to the processing requirements.
2. For extrusion, thermoforming or blow molding, when maximum part rigidity is the primary objective, a low melt index (higher molecular weight), high density resin is recommended.
3. To obtain maximum environmental stress-crack resistance for extruded, thermoformed or blow molded packaging applications, a low-melt index (higher molecular weight) copolymer should be used.

Table 1 summarizes the general HDPE packaging guidelines based on packaging tests performed to date. From these tests, it can be determined which classes of products are packageable in HDPE. For example, most alcohols, ketones, or water soluble and water-based chemicals are packageable in HDPE, while some strong oxidizing agents (even though they are water based) cannot be successfully contained for any reasonable storage period.

Aromatic hydrocarbons permeate polyethylenes beyond acceptable packaging limits, and halogenated hydrocarbons permeate small polyethylene containers almost 100% in a short period of time.

TABLE 1  
**General Guidelines for HDPE Packaging**

### Water-Based Products

Most water-based products like household bleach and detergents are packageable. Gas permeation may be a problem with some products. Oxygen permeation into a container causes catsup to darken, and carbon dioxide is quickly lost from a carbonated beverage.

### Aliphatic Hydrocarbons

High molecular weight products such as mineral oils, vegetable oils and motor oil can be packaged, although some consideration should be given to package deformation and permeability. Package size becomes important for such low molecular weight products as heptane and hexane. DOT regulations should also be reviewed.

### Aromatic Hydrocarbons

Most of these products permeate excessively and cause package deformation. Typical products are benzene and orange oil.

### Halogenated Hydrocarbons

Permeation levels are high and package deformation excessive. Carbon tetrachloride is an example.

### Alcohols, Ketones, Aldehydes

Most of these products are packageable. Some may cause stress-cracks, but good resin selection can eliminate this problem. Package size is often the determining factor in many cases. Ethylene glycol and ethyl alcohol are both packageable.

### Acids

Most acids are packageable; however, strong oxidizing acids like concentrated nitric acid and fuming sulfuric are exceptions. Two commercially packaged products are hydrofluoric acid and battery acid, which is dilute sulfuric.

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## PACKAGING TEST RESULTS

Data on the packageability of various products (such as food products, pharmaceuticals, industrial chemicals, etc.) in Marlex® high density polyethylene is presented in Appendix I. Although this data is useful in determining the effect a product will have on the resin, the importance of package design cannot be ignored. Such factors as wall thickness, part size and part geometry can make the difference between an acceptable or unacceptable package. This is especially true for those products that affect the package by such means as permeation, softening or distortion.



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## CHEMICAL RESISTANCE

To be suitable as a packaging material, the plastic must not have a chemical reaction to the product being packaged. The level of chemical resistance can be measured by the retention or loss of its physical properties. Chemical resistance is especially dependent on temperature, and the storage shelf life may have a significant bearing. Marlex® HDPE is considered a very effective packaging material, since it is one of the most chemically resistant plastics commercially available.

The chemical resistance data shown in Appendix I was obtained by immersing ASTM D638, Type IV tensile bars in the testing media for as long as three months at 80°F, 120°F and 150°F, then checking for weight change, tensile strength, staining, softening and embrittlement. The results are reported as follows:

### Excellent

This product had no effect on Marlex® HDPE.

### Good

Slight absorption occurs, but has little or no effect on the physical properties.

### Fair

A loss of physical properties occurs. Package design and use conditions will determine whether or not HDPE can be used.

### Poor

Significant loss of strength, softening or embrittlement occurs. High density polyethylenes are unsuitable for prolonged contact.

These classifications have been based on continuous exposure to the product for extended periods of time. A rating of "poor" does not always mean that the chemical environment would have an adverse effect on a Marlex® HDPE package. If the exposure period were very short, even at an elevated temperature, the package might still be acceptable. Only sufficient testing can confirm the suitability of the package. Additional chemical resistance data are shown in Appendix II.

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## PERMEABILITY

Permeation is one of the main factors governing the use of HDPE containers in product packaging. Primarily, permeation is considered a physical migration of a product through the container walls and its subsequent vaporization from outside surfaces. Obviously, an appreciable loss of product during shelf storage would prohibit a container's use in packaging applications. A weight loss of 3% per year (with no visual changes or substantial permeation of an essential component) is generally recognized as the maximum product loss acceptable.

If permeation is borderline, i.e., slightly above 3%, packaging in a large container may still prove acceptable due to the increased volume/surface-area ratio.

The permeability results shown in Appendix I were obtained using 4 oz. Boston Round bottles, filled with the liquid and stored for 4 months at 80°F. The bottles were weighed periodically and the average loss rate of the contents per week was established. The average loss per year was then calculated, and expressed as a percent of the original liquid weight. This is similar to the procedure described in ASTM D2684.

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## PRODUCT ALTERATION

As a result of permeation, product alteration can occur. There is the possibility that outside elements could permeate into a container and cause a weight gain. However, a weight gain or loss in a complex mixture of chemicals could change the concentration of key ingredients in the total product, making the package unreliable. For example, many perfumes and cosmetic products cannot be packaged in HDPE because, while the product base is contained, the scent is lost.

Another form of product alteration is the reaction of the product with a minute quantity of oxygen permeating through the walls into the headspace of the container. Normally, this small amount of oxygen is not prohibitive. In some products, however, a discoloration or an actual change of the active ingredients can occur. Product taste is another factor to be considered.

These potential product alterations highlight the necessity to pre-determine the effects of a proposed package on the product.

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## ENVIRONMENTAL STRESS-CRACK RESISTANCE

The environmental stress crack resistance of a container is a combination of the inherent resistance of the resin, the design and molding quality of the finished container, and the type of product packaged.

### PREMIUM EXTRUSION AND RIGID PACKAGING RESINS

Under certain conditions, HDPE may exhibit mechanical failure by cracking. Even though ESCR test results may be negative under a given set of circumstances, there are several options that can be used to help rectify the situation. For example, a more resistant (higher molecular weight) resin, or a change in container design or manufacturing technique may be employed separately or in combination to overcome many environmental stress-crack problems.

To determine whether or not a liquid product will cause stress-crack, tests can be run on compression molded sheets using ASTM D1693. This is commonly referred to as the Bell Laboratory bent strip test. Often, it is desirable to test the container itself for stress-crack resistance. In this case, ASTM D2561 is a suitable test procedure. Appendix I includes the results of stress-crack testing.

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## GAS PERMEABILITY

As indicated by the data in Appendix I, high density polyethylene is an excellent barrier for many products, including gases. Table 2 summarizes the permeability rate of some common gases through Marlex® HDPE. Since the permeability rate is influenced by the density of the barrier as well as functional groups of the permeating gas, these rates are considerably lower than those obtained with low density polyethylene.

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TABLE 2  
**Gas Permeability of Marlex® HDPE**

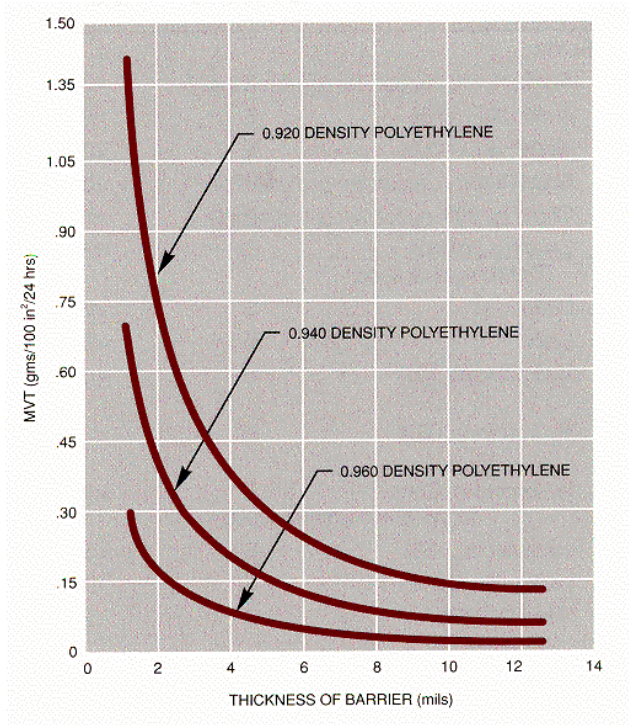
Gas	Rate
	cc/mil/24 hrs/100 in <sup>2</sup>
Carbon Dioxide	345
Ethane	236
Hydrogen	321
Natural Gas	113
Oxygen	111
Freon 12	95
Helium	247
Nitrogen	53
Sulfur Dioxide	306

## WATER VAPOR TRANSMISSION

In many packaging applications, HDPE is used because of its moisture barrier properties. As with other gases and liquids, the density of the barrier affects the transmission rate; i.e., the higher the density the more efficient the barrier.

Figure 1 shows the effect of film thickness and density on the water vapor transmission through three polyethylene resins of different densities. This indicates that at any given film thickness the high density film is the superior barrier. These data were obtained by ASTM E96, Procedure E, which specifies a temperature of 100°F and 90% relative humidity.

FIGURE 1  
**Effect of Film Thickness on  
 Water Vapor Transmission**



## SUMMARY

The list of products packaged in HDPE has grown considerably in recent years. Chevron Phillips Chemical has established itself as a leader in the plastics packaging arena by offering consistently high quality Marlex® HDPE resins, backed by knowledgeable Plastics Technical Center support. Our outstanding technical staff has developed specialized grades of Marlex® resins to meet the varying requirements of such products as light weight milk bottles, durable and resealable motor oil "cans", and laundry detergent/bleach containers.

For additional information on a Marlex® resin suited to your packaging needs, please contact our Sales and Marketing groups for help. Detailed contact information is provided at the end of this document.

## Support Information

The appendixes on the following pages present detailed packageability and chemical resistance information for our Marlex® HDPE resins.



## APPENDIX 1

### Packageability of Various Products in Marlex® HDPE

Product	Chemical Resistance	Permeability % Loss/Year	Can Cause Stress Cracking?	Remarks
<b>Acids</b>				
Acetic, 1 - 10%	E	<3	Yes	
Acetic, 10 - 60%	E	<3	Yes	
Acetic, 80-100%	E	<3	Yes	
Aqua Regia	P	<3	-	Attack occurs at ambient temperature.
Chromic, 20%	E	<3	No	
Cleaning Solution (Dichromate-Sulfuric)	G	<3	No	Staining and brittleness will occur at elevated temperature.
Citric	E	<3	No	
Gallic	E	<3	No	
Hydrochloric, 10%	E	<3	No	A slight staining may occur at elevated temperature.
Hydrochloric, 35%	E	<3	No	A slight staining may occur at elevated temperature.
Hydrochloric, Conc.	E	<3	No	A slight staining may occur at elevated temperature.
Hydrofluoric, 75%	E	<3	No	
Lactic, 10 - 90%	E	<3	No	
Nitric, 0 - 30%	G	<3	No	A slight staining may occur at elevated temperature.
Nitric, 30 - 50%	G	<3	No	Staining will occur at elevated temperature.
Nitric, 95 - 98%	P	<3	-	Staining and brittleness will occur at ambient temperature.
Phosphoric, 30 - 90%	E	<3	No	
Stearic, 100%	E	-	No	
Sulfuric, 70%	G	<3	No	Stiffening and embrittlement will occur at elevated temperature.
Sulfuric, 80%	G	<3	No	Stiffening and embrittlement will occur at elevated temperature.
Sulfuric, Fuming	P	<3	No	Stiffening and embrittlement will occur at elevated temperature.
<b>Bases</b>				
Ammonium Hydroxide, 30%	E	<3	No	
Barium Hydroxide, 30%	E	<3	No	
Calcium Hydroxide, 30%	E	<3	No	
Potassium Hydroxide, 30%	E	<3	No	
Sodium Hydroxide, 30%	E	<3	No	

Legend: E – Excellent G – Good F – Fair P – Poor

## APPENDIX 1

### Packageability of Various Products in Marlex® HDPE

Product	Chemical Resistance	Permeability % Loss/Year	Can Cause Stress-Cracking?	Remarks
<b>Food &amp; Food Products</b>				
Beet Juice	E	<3	No	A slight staining will occur.
Beer	E	<3	No	
Carrot Juice	E	<3	No	
Catsup (tomato based sauce)	E	<3	No	A slight staining will occur.
Cherries	E	<3	No	A slight staining will occur.
Cider	E	<3	Yes	
Cocoa, hot	E	<3	No	
Coffee, hot	E	<3	No	
Cola	E	<3	No	
Dyes (Vegetable)	E	<3	No	
Gelatine	E	Nil	No	
Gin	E	<3	No	
Glucose, Saturated	E	<3	No	
Lard	G	<3	Yes	Container distortion may occur.
Lemon Juice	E	<3	No	
Margarine	G	<3	Yes	
Marmalade & Jam	E	<3	No	
Milk	E	<3	No	
Molasses	E	<3	No	
Orange Extract	E	<3	No	
Prune Juice	E	<3	No	A slight staining will occur.
Salt (sodium chloride)	E	Nil	No	
Sugar	E	Nil	No	
Tomato Juice	E	<3	No	A slight staining will occur.
Vinegar	E	<3	Yes	
Vanilla Extract	E	<3	Yes	
Whiskey	E	<3	No	
Wine	E	<3	No	
Yeast	E	Nil	No	

## APPENDIX 1

### Packageability of Various Products in Marlex® HDPE

Product	Chemical Resistance	Permeability % Loss/Year	Can Cause Stress-Cracking?	Remarks
<b>Household, Toiletries &amp; Pharmaceutical Products</b>				
Bleaches	E	<3	No	
Deodorants (all types)	E	<3	No	
Detergents (standard)	E	<3	Yes	
Detergents (heavy duty)	E	<3	Yes	
Dry Cleaners	G	<3	Yes	
Glycerine	E	<3	No	
Hair Oil	E	<3	Yes	
Hair Shampoo	E	<3	Yes	
Hair Wave Lotions	E	<3	Yes	
Hand Creams	E	<3	Yes	
Hydrogen Peroxide, 3%	E	<3	No	
Inks	E	<3	No	A slight staining may occur.
Iodine (tincture)	G	<3	No	A light staining and embrittlement may occur after prolonged use.
Lighter Fluid	G	High	Yes	
Lipstick	E	Nil	No	Some staining may occur.
Mascara	E	Nil	No	
Mercurochrome	G	<3	No	Some staining may occur after prolonged use.
Nail Polish	F	4	Yes	Some softening will occur after prolonged contact
Rouge	E	Nil	No	
Shaving Lotion	G	<3	Yes	Some stiffening will occur.
Shoe Polish (liquid)	G	High	Yes	Some stiffening will occur.
Shoe Polish (paste)	G	-	Yes	Some staining will occur.
Soap	E	<3	Yes	
Suntan Lotion	E	<3	No	
Turpentine	P	8.5	No	
Wax (liquid & paste)	E	<3	Yes	

## APPENDIX 1

### Packageability of Various Products in Marlex® HDPE

Product	Chemical Resistance	Permeability % Loss/Year	Can Cause Stress-Cracking?	Remarks
<b>Industrial Chemicals</b>				
Acetone	G	3.4	No	A slight softening will occur.
Alums (all types) Conc.	E	<3	No	
Ammonium Nitrate, Sat'd	E	<3	No	
Amyl Acetate	G	4.0	No	A slight softening will occur.
Amyl Alcohol, 100%	E	<3	Yes	
Amyl Chloride, 100%	G	High	No	Softening will occur.
Benzaldehyde	E	<3	No	
Benzene	G	High	No	
Boric Acid, Conc. Solution	E	<3	No	
Butyl Alcohol	E	<3	No	
Calcium Chloride Saturated Solution	E	<3	No	
Carbon Tetrachloride	P	80	Yes	Softening and part deformation will occur at elevated temperature.
Chlorobenzene	P	High	Yes	Softening and part deformation will occur
Chloroform	P	High	Yes	Softening and part deformation will occur
Cyclohexanol	G	<3	Yes	
Developers, Photographic	E	<3	No	
Dibutylphthalate	E	<3	No	
Ethylene Glycol	E	<3	No	
Ethyl Acetate	F	9	No	Softening and part deformation will occur.
Ethyl Alcohol	E	<3	Yes	
Ethyl Ether	F	140	No	Softening and part distortion will occur.
Ethylene Chloride	P	High	No	Softening and part distortion will occur.
Formaldehyde, 40%	E	<3	No	
Furfural, 100%	E	<3	No	
Gasoline	G	High	No	
Glycerol	E	<3	No	
Mercury	E	Nil	No	
Methyl Alcohol	E	<3	Yes	
Phenol, 90%	E	<3	No	
Pickling & Plating Solution	E	<3	No	Sulfuric acid/nitric acid mixtures will cause embrittlement at high temp.



## APPENDIX 1

### Packageability of Various Products in Marlex® HDPE

Product	Chemical Resistance	Permeability % Loss/Year	Can Cause Stress-Cracking?	Remarks
<b>Industrial Chemicals</b>				
Potassium Dichromate	E	Nil	No	
Propyl Alcohol	E	<3	Yes	
Silver Nitrate Solution	E	<3	No	
Sodium Bicarbonate, Sat'd.	E	<3	No	
Toluene	P	High	No	Softening, swelling and part distortion will occur.
Trichloroethylene	P	High	No	Softening, swelling and part distortion will occur.
<b>Oils</b>				
Camphor	F	High	No	A slight softening will occur.
Castor	G	<3	Yes	A slight softening will occur at elevated temperature
Cottonseed	G	<3	Yes	A slight softening and part distortion will occur at high temp.
Linseed	G	<3	No	A slight softening and part distortion will occur at elevated temperature
Mineral	G	<3	Yes	A slight softening and part distortion will occur.
Motor Oil (SAE 10)	G	<3	No	A slight softening and part distortion will occur at high temp.
Orange	G	High	No	A slight softening and part distortion will occur
Peppermint	G	High	Yes	A slight softening and part distortion will occur
Transformer	G	<3	No	A slight softening and part distortion will occur
Vegetable	G	<3	Yes	A slight softening and part distortion will occur at high temp.
Pine	G	High	Yes	A slight softening and part distortion will occur.

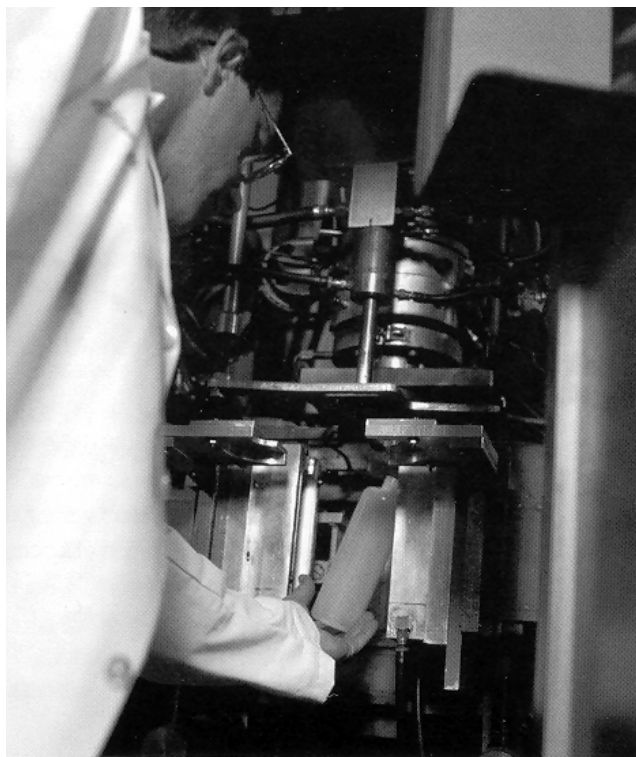
Legend: E – Excellent G – Good F – Fair P – Poor

## APPENDIX II

### Chemical Resistance of Polyethylene

Chemical attack may be accompanied by any one, or a combination of the following: swelling, discoloration, brittleness or loss of strength. The following data are derived from laboratory tests using non-stressed immersed specimens under static conditions. The ratings shown are based mainly on chemical attack, solvent swelling and changes in physical properties under such conditions.

Legend: "S" - Satisfactory  
"O" - Some attack  
"U" - Unsatisfactory



Coextrusion blow molding at Bartlesville Technology Center

Reagent	High Density	
	70 °F	140 °F
Acrylic Emulsions	S	S
Aluminum Chloride Dilute	S	S
Aluminum Chloride Concentrated	S	S
Aluminum Fluoride Concentrated	S	S
Aluminum Sulfate Concentrated	S	S
Ammonia 100% Dry Gas	S	S
Ammonium Carbonate	S	S
Ammonium Chloride Saturated	S	S
Ammonium Fluoride 20%	S	S
Ammonium Metaphosphate Saturated	S	S
Ammonium Persulfate Saturated	S	S
Ammonium Sulfate Saturated	S	S
Ammonium Sulfide Saturated	S	S
Ammonium Thiocyanate Saturated	S	S
Aniline 100%	S	--
Antimony Chloride	S	S
Barium Carbonate Saturated	S	S
Barium Chloride Saturated	S	S
Barium Sulfate Saturated	S	S
Barium Sulfide Saturated	S	S
Benzene Sulfonic Acid	S	S
Bismuth Carbonate Saturated	S	S
Black Liquor	S	S
Borax Cold Saturated	S	S
Boric Acid Dilute	S	S
Bromic Acid 10%	S	S
Bromine Liquid 100%	O	U
Butanediol 10%	S	S
Butanediol 60%	S	S
Butanediol 100%	S	S
Butyl Acetate 100%	O	U
Calcium Bisulfide	S	S
Calcium Carbonate Saturated	S	S
Calcium Chlorate Saturated	S	S
Calcium Hypochlorite Bleach Solution	S	S
Calcium Nitrate 50%	S	S
Calcium Sulfate	S	S
Carbon Dioxide 100% Dry	S	S
Carbon Dioxide 100% Wet	S	S
Carbon Dioxide Cold Saturated	S	S
Carbon Disulfide	-	U
Carbon Monoxide	S	S
Chlorine Liquid	O	U
Chlorosulfonic Acid 100%	U	U
Chrome Alum Saturated	S	S
Chromic Acid 50%	S	O
Cider	S	S
Coconut Oil Alcohols	S	S
Copper Chloride Saturated	S	S
Copper Cyanide Saturated	S	S
Copper Fluoride 2%	S	S
Copper Nitrate Saturated	S	S
Copper Sulfate Dilute	S	S
Copper Sulfate Saturated	S	S
Cuprous Chloride Saturated	S	S
Cyclohexanone	U	U

Reagent	High Density	
	70 °F	140 °F
Dextrin Saturated	S	S
Dextrose Saturated	S	S
Disodium Phosphate	S	S
Diethylene Glycol	S	S
Emulsions Photographic	S	S
Ethyl Chloride	O	U
Ferric Chloride Saturated	S	S
Ferric Nitrate Saturated	S	S
Ferrous Chloride Saturated	S	S
Ferrous Sulfate	S	S
Fluoboric Acid	S	S
Fluorine	S	U
Fluosilicic Acid 32%	S	S
Fluosilicic Acid Concentrate	S	S
Formic Acid 20%	S	S
Formic Acid 50%	S	S
Formic Acid 100%	S	S
Fructose Saturated	S	S
Fuel Oil	S	U
Glycol	S	S
Glycolic Acid 30%	S	S
Hydrobromic Acid 50%	S	S
Hydrocyanic Acid Saturated	S	S
Hydrochloric Acid 30%	S	S
Hydrofluoric Acid 40%	S	S
Hydrofluoric Acid 60%	S	S
Hydrogen 100%	S	S
Hydrogen Bromide 10%	S	S
Hydrogen Chloride Gas Dry	S	S
Hydroquinone	S	S
Hydrogen Sulfide	S	S
Hypochlorous Acid Concentrated	S	S
Lead Acetate Saturated	S	S
Magnesium Carbonate Saturated	S	S
Magnesium Chloride Saturated	S	S
Magnesium Hydroxide Saturated	S	S
Magnesium Nitrate Saturated	S	S
Magnesium Sulfate Saturated	S	S
Mercuric Chloride	S	S
Mercuric Cyanide Saturated	S	S
Mercurous Nitrate Saturated	S	S
Methyl Ethyl Ketone 100%	U	U
Methyl Bromide	O	U
Methylsulfuric Acid	S	S
Methylene Chloride 100%	U	U
Nickel Chloride Saturated	S	S
Nickel Nitrate Concentrated	S	S
Nickel Sulfate Saturated	S	S
Nicotinic Acid	S	S
Nitric Acid <50%	S	O
Nitrobenzene 100%	U	U
Oleum Concentrated	U	U
Oxalic Acid Dilute	S	S
Oxalic Acid Saturated	S	S
Petroleum Ether	U	U
Phosphoric Acid 0 - 30%	S	S
Phosphoric Acid 90%	S	S
Photographic Solutions	S	S
Potassium Bicarbonate Saturated	S	S
Potassium Borate 1%	S	S
Potassium Bromate 10%	S	S

Reagent	High Density	
	70 °F	140 °F
Potassium Bromide Saturated	S	S
Potassium Carbonate	S	S
Potassium Chlorate Saturated	S	S
Potassium Chloride Saturated	S	S
Potassium Chromate 40%	S	S
Potassium Cyanide Saturated	S	S
Potassium Ferri/Ferro Cyanide	S	S
Potassium Fluoride	S	S
Potassium Nitrate Saturated	S	S
Potassium Perborate Saturated	S	S
Potassium Perchlorate 10%	S	S
Potassium Permanganate 20%	S	S
Potassium Sulfate Concentrated	S	S
Potassium Sulfide Concentrated	S	S
Potassium Sulfite Concentrated	S	S
Potassium Persulfate Saturated	S	S
Propargyl Alcohol	S	S
Propylene Glycol	S	S
Rayon Coagulating Bath	S	S
Sea Water	S	S
Shortening	S	S
Silicic Acid	S	S
Sodium Acetate Saturated	S	S
Sodium Benzoate 35%	S	S
Sodium Bisulfate Saturated	S	S
Sodium Bisulfite Saturated	S	S
Sodium Borate	S	S
Sodium Bromide Oil Solution	S	S
Sodium Carbonate Concentrated	S	S
Sodium Carbonate	S	S
Sodium Chlorate Saturated	S	S
Sodium Chloride Saturated	S	S
Sodium Cyanide	S	S
Sodium Dichromate Saturated	S	S
Sodium Ferricyanide Saturated	S	S
Sodium Ferrocyanide	S	S
Sodium Fluoride Saturated	S	S
Sodium Nitrate Sodium Sulfate	S	S
Sodium Sulfide 25% to Saturated	S	S
Sodium Sulfite Saturated	S	S
Stannous Chloride Saturated	S	S
Stannic Chloride Saturated	S	S
Starch Solution Saturated	S	S
Sulfuric Acid <50%	S	S
Sulfuric Acid 96%	O	U
Sulfuric Acid 98% Concentrated	O	U
Sulfurous Acid	S	S
Tannic Acid 1 0%	S	S
Tartaric Acid Saturated	--	--
Tetralin	U	U
Tetrahydrofuran	O	O
Transformer Oil	S	O
Trichloroacetic Acid 10%	S	S
Trisodium Phosphate Saturated	S	S
Urea	S	S
Urine	S	S
Wetting Agents	S	S
Xylene	U	U
Zinc Chloride Saturated	S	S
Zinc Sulfate Saturated	S	S



If we may be of further assistance, please contact our Polyethylene Sales and Marketing team. Contact information is available at this web site <http://www.cpchem.com/index.asp>, along with links to our polyethylene resins and MSDS sheets.

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Additional information regarding the chemical resistance of Marlex<sup>®</sup> polyethylene is presented in other Plastic Technical Center publications. This data is provided for use only as guidelines in preliminary determination of packageability because chemical compatibility is highly dependent on storage and use conditions. Furthermore, many products are combinations of chemicals so the ultimate compatibility with the packaging material involves testing the combination of the product material and its proposed container.

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